

1

3

## 4

5

## 6

7

9

## 10

## 11

12

## 13

14

## 15

16

17

18

19

I hereby certify that this correspondence is being deposited with the United States Postal Service on the date shown below in an envelope as "Express Mail Post Office to Addressee": Mailing Label Number ET 100 563 389 US addressed to the Assistant Commissioner of Patents, Washington, D.C., 20231.

Date:

12-4-01

Kenneth A. Keeling  
Registration No. 31,842

1 bran layer) in a dry or slightly moistened condition.

2 One of the necessary steps in the dry corn milling process, whether the milled  
3 product is to be used for the production of methanol, starch, flakes, grits or flour,  
4 involves separation of the bran layer and the germ (also referred to as embryo) from the  
5 endosperm, which is then processed further to produce the milled corn product.

6 In a typical dry milling process, corn kernels are cleaned to remove extraneous  
7 material. The cleaned corn is tempered with water or steam then passed through a  
8 degerminating mill to release the hull from the germ and endosperm.

9 Traditionally, germ has been removed from corn kernels during milling through  
10 the use of a "Beall" type degerminator. In the Beall type of degerminator, corn is fed into  
11 and through the annulus formed between a rotating, conical rotor and a stationary  
12 concentric screen made of perforated metal. Both rotor and screen are textured with large  
13 nodes, which impede motion of the kernels as they turn with the rotor. A weighted  
14 discharge plate provides a method of controlling pressure and corn density within the  
15 chamber. In this process, the germ is dislodged from the endosperm by impact and  
16 bending stress as the kernels move through the annulus. In practice, most of the kernels  
17 are broken during the process. Typically, this process produces an effective recovery of  
18 endosperm particles of which approximately twenty to thirty percent of the endosperm  
19 pieces will be retained on a No. 6 standard sieve cloth. Because a significant portion of  
20 the bran layers may still adhere to the pieces of endosperm after the degermination  
21 process, further refinement of the endosperm may be required to reduce the fiber content  
22 of the endosperm product.

23 Inherent inefficiencies in refining and recovery processes result in increased  
24 processing costs and a reduction in the overall yield of low fat corn products.

1 For any of the milled corn products, the production of low fat products is  
2 desirable. In general, it is desirable during the degermination stage of the corn milling  
3 process to produce large particles of endosperm that are largely free of bran and germ.  
4 Though the degermination process can be destructive to the corn kernels, it is generally  
5 desirable to minimize the production of fine particles of endosperm, as the fine particles  
6 are difficult to separate from the bran and germ particles in order to recover them as a  
7 corn product. Maximizing the production of large particles of endosperm thus offers  
8 maximum yields of corn products and improves the quality of the products.

9 U. S. Patent No. 5,250,313 to Giguere (a continuation-in-part of U. S. Patent No.  
10 4,189,503) describes a degerminating process wherein the corn kernels are crushed from  
11 the thin edges toward the center while avoiding crushing of the relatively flat side  
12 surfaces. The crushing force fractures the endosperm under and around the germ and  
13 squeezes the germ away from the endosperm. A machine for carrying out the  
14 degermination includes relatively rotating discs having corrugations in their facing  
15 surfaces in which the kernels are caught and crushed from the thin edges toward the  
16 center. An alternative degerminator machine includes a single rotating disc having curved  
17 guide vanes on its upper surface for guiding the kernels as they are propelled outwardly  
18 by centrifugal force.

19 U. S. Patent No. 6,254,914 describes a wet-milling process for recovery of corn  
20 coarse fiber (pericarp) including the steps of: soaking corn in water to loosen the  
21 attachments of various corn components therein to each other, degerminating the soaked  
22 corn to strip the corn coarse fiber and the germ away from the endosperm, recovering the  
23 germ, and recovering the corn coarse fiber by flotation. The degerminating step of such

1 process involves grinding the kernels in a degermination mill such as a Bauer mill so that  
2 the pericarp and germ are stripped away from the endosperm.

3 U. S. Patent No. 4,181,748 to Chwalek, et al. describes a combined dry-wet  
4 milling process for refining corn comprising dry milling corn kernels to provide an  
5 endosperm fraction, a germ fraction, a fiber (hull) fraction and a cleanings fraction, wet  
6 milling the endosperm fraction including using two distinct steeping steps, one upstream  
7 and the other downstream of an impact milling step, to provide a mill starch slurry. The  
8 process further comprises removing fine fiber tailings from the mill starch slurry,  
9 separating the slurry into a starch-rich fraction and protein-rich fraction, concentrating the  
10 protein-rich fraction, directly combining the fiber (hull), cleanings, fine fiber tailings and  
11 protein-rich concentrate without removing corn oil therefrom, with the germ fraction to  
12 provide a wet animal feed product, and drying the feed product.

13 U. S. Patent No. 4,301,183 to Giesfeldt et al. discloses a method and apparatus for  
14 degerminating a corn kernel by impelling the kernels along a guide vane into an impact  
15 surface including a horizontal disc having a plurality of guide vanes extending in a  
16 curvilinear path with each vane terminating in an end portion that is substantially parallel  
17 to a tangent to the disc. A plurality of impact surfaces are provided in the same  
18 horizontal plane as the disc with each surface being substantially linear and extending  
19 transversely of the path of travel of a kernel impelled by the disc.

20 The prior art processes result in a high percentage of fine particles of endosperm  
21 that are difficult to separate from the bran and germ particles in order to recover them as  
22 a corn product.

23 Cylindrical, rubberized rollers have been used to remove hulls from other grains,  
24 particularly rice. Rollers for removing hulls from grains are described in U. S. Patent No.

1 3,104,692 to Davis et al. dated September 24, 1963, U. S. Patent No. 4,066,012 to Satake  
2 and U. S. Patent No. 5,678,477 to Satake et al. Despite the use of such rollers for  
3 removing hulls from grains and the long-standing need to separate corn germ from  
4 endosperm with a minimum amount of fine endosperm particles, the use of rubberized  
5 rollers and the process of the present invention have not been previously practiced.

6

## 7 BRIEF SUMMARY OF THE INVENTION

8 Accordingly, it is an object of the present invention to provide a process for  
9 increasing the production of large particles of endosperm, and thus maximize yields of  
10 low-fat corn products and improve the value of the products.

11 The present invention provides a process to remove the bran from the corn kernel,  
12 and the germ from the endosperm of a corn kernel. The apparatus of the present  
13 invention comprises opposing cylindrical rollers, each roller rotating about an axis; the  
14 axis of the rollers substantially parallel. The roller bodies have rubberized coverings,  
15 rotate with differing surface velocities and are controlled so as to impart shearing friction  
16 forces to corn kernels drawn between the rollers. The process of the present invention  
17 includes a tempering step comprising adding an amount of moisture to the corn and  
18 soaking the corn to soften the bran; a polishing step for removing bran layers from the  
19 corn; a second tempering step comprising adding an amount of moisture to the corn and  
20 soaking the corn to expand the germ; and a friction step to remove germ from the  
21 endosperm.

22

## BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 depicts a schematic diagram of a degermination process incorporating the process of the present invention.

Figure 2 depicts a cross-sectional top view of a corn kernel with the bran in place.

Figure 3 depicts a front view of a corn kernel with the bran removed.

Figure 4 depicts a side view of a corn kernel with the bran removed.

## DETAILED DESCRIPTION OF THE INVENTION

Referring first to Fig. 1, 2 and 3, a corn kernel 100 is depicted for reference as to terms used herein. A typical corn kernel 100 includes a germ 104 and an endosperm 106 that are totally covered in a casing of bran 102. The germ 104 is embedded in one of the large, relatively flat sides 108 of kernel 100.

Referring to Fig. 1, the process of the present invention is depicted as a process flow diagram.

In the process of the present invention a measured amount of raw, clean corn kernels are first introduced into a first tempering mixer 200 where a measured amount of water 500 is added. The water 500 may be in various forms including water, steam or an aqueous solution. The first tempering mixer 200 comprises a generally cylindrical housing 206 having a central axis 208 and a co-axial auger 210. The auger 210 comprises a rotating shaft 212 having angled paddles 214, the angled paddles 214 transmitting the corn kernels (not shown) from a first inlet end 202 of the first tempering mixer 200 to a second outlet end 204 of the first tempering mixer 200. The rotating auger 210 distributes the water 500 on the corn kernels for complete wetting of the corn kernels to provide for even penetration of moisture.

1           Tempering mixers 200 are commonly used in the industry to provide uniform  
2 wetting of corn kernels. A suitable, commercially available tempering mixer is  
3 manufactured and sold by the Satake Corporaion and identified as a Technovator, model  
4 STMA.

5           The corn kernels are then transferred to a holding tank 300 where they are  
6 retained until the kernels obtain a desired level of moisture absorption, a process referred  
7 to as tempering. Tempering softens and expands the bran 102 layers, but does not last so  
8 long as to provide significant penetration of water 500 in the germ 104 or endosperm 106.  
9 Such moisturization makes the bran 102 more pliable, and weakens the bond between the  
10 wetted bran 102 and the less-absorbent germ 104 and endosperm 106, allowing the bran  
11 to be removed without disturbing the germ 104 or the endosperm 106.

12           Holding time in the holding tank 300 is typically three (3) to fifteen (15) minutes,  
13 depending on the variety of corn and the desired level of moisturization. In an exemplary  
14 embodiment the corn kernels are handled in a first-in, first-out basis and adding about 5%  
15 water by weight is sufficient moisturization. The invention allows for a varied range of  
16 moisture levels as needed in the resulting products for optimizing intended further  
17 processing.

18           The corn kernels are next introduced into a polishing machine 400, which consists  
19 of a rotating eccentric rotor 410 surrounded by a polygonal perforated metal screen 412.  
20 As the clearance between the screen 412 and the rotor 410 changes during each rotation,  
21 the corn kernels experience alternating cycles of compression and relaxation, producing  
22 an effective rubbing action. The polishing machine 400 ruptures the softened bran 102,  
23 which softened bran 102 leaves the milling chamber through the perforations in the  
24 screen 412.

1 A quantity of bran 102 remains attached to the corn kernel 100 after the polishing  
2 step. The remaining bran 102 is usually attached to the pointed end of the germ 104. The  
3 amount of bran 102 left on the germ 104 can be controlled and may be varied in relation  
4 to the desired end product from the processing. A controlled amount of bran still  
5 attached to the germ 104 is desired to assist in frictional removal of the germ 104 from  
6 the endosperm 106, and to increase the moisture content of the finished product (germ  
7 104, with a small percentage of bran 102). The processor can use the amount of bran 102  
8 left on the germ 104 to control the process and the finished product.

9 Polishing machines come in various configurations. A suitable, commercially  
10 practiced polishing machine 400 is manufactured by Satake USA and identified as a Mist  
11 Polisher. The typical polishing machine segregates the bran 102 from the remaining parts  
12 of kernel 100. If a polishing machine is configured not to segregate the separated  
13 components, an independent separation procedure may be accomplished subsequently in  
14 the process.

15 The bran 102 consists of a number of layers (individual layers not shown). The  
16 layers have differing properties and the potential for differing uses. The different layers  
17 of the bran 102 also absorb moisture at different rates. The present process allows for  
18 bran 102 removal to be done selectively by layer through one or more iterations of the  
19 tempering mixer 200, the holding tank 300 and the polishing machine 400.

20 Once the bran 102 is removed from the corn kernel 100, a controlled amount of  
21 moisture is again added to the corn kernels with a second tempering mixer 600, as  
22 previously done in the first tempering mixer 200. The corn kernels are then transported  
23 to a second holding tank 700 and tempered. During this period, moisture swells the germ  
24 104, which absorbs the moisture more quickly than the endosperm 106, and loosens the



1 bond between the germ 104 and the endosperm 106. The holding time may vary  
2 depending on the amount of moisture absorption required, but should not be long enough  
3 to break down the inter-cellular bonds of the starch of the endosperm 106, as such break-  
4 down promotes breakage of the endosperm 106.

5 The corn kernels are then fed between two cylindrical rollers 802 and 804 that are  
6 covered with rubber, polyurethane or other material having suitable elastic properties.  
7 The two rollers 802 and 804 rotate at differing surface speeds in different directions, so  
8 the adjacent surfaces move the same direction. Because friction mandates that an object  
9 in contact with either roller 802 or 804 will attempt to move at the same linear speed as  
10 the surface of the roller, a shear force develops across the kernel 100, from the difference  
11 in linear speed applied to the two different sides of the kernel 100. This action causes the  
12 germ 104 to break away from the endosperm 106. The material covering the rollers must  
13 be sufficiently elastic to engage the corn kernels 100 gently enough to avoid cracking or  
14 crushing the kernels 100, yet rigid enough to resist rapid wear of the material. A stiff  
15 rubber or relatively dense polyurethane has been determined to have characteristics  
16 consistent with such requirement.

17 At least one of the rollers 802 or 804 is adjustable in relationship to the other so  
18 that the friction applied between the roller surfaces may be adjusted to provide sufficient  
19 friction to various size corn kernels to tear the germ 104 from the endosperm 106, but to  
20 avoid pulverizing the kernel 100.

21 The adjustability of inter-roller friction may be accomplished by varying the  
22 differential tangential velocity of the rollers, varying the gap between the rollers,  
23 tensioning the distance between the rollers with springs, pneumatic pistons or other  
24 tensioning device. Interactive assessment of the applied friction may be accomplished by

1 monitoring the amperage drain of the roller motors, the air pressure in a pneumatic  
2 piston, the amperage of the air pressure production pump feeding the pneumatic piston,  
3 or other means.

4 In practice, the application of such friction will result in breaking away the germ  
5 104 from the endosperm 106, and may also result in tearing of the endosperm 106,  
6 resulting in endosperm 106 particles. By minimizing the production of particles and by  
7 maximizing the size of particles produced, the highest value of the kernel may be  
8 realized. Endosperm 106 particles produced as a result of process of the present  
9 invention tend to be relatively large as such particles are produced as a result of a shear  
10 force rather than an impact force.

11 Germ 104 maintained in its whole state provides greater oil production.  
12 Endosperm 106 maintained in its whole segments or large particle state is suitable for  
13 high value end-product uses.

14 The resulting mixture of germ 104 and endosperm 106 may be separated by  
15 various methods. An exemplary method is to allow the mixture to fall through a rapidly  
16 moving column of air. The lighter germ 104 particles are lifted and separated from the  
17 heavier endosperm 106, and are collected and discharged separately.

18 A suitable, commercially practiced apparatus including cylindrical rollers and a  
19 rapidly moving column of air is a Rubber Roll Husker and Aspirator sold by Satake USA.  
20 Prior to the present invention such Rubber Roll Husker and Aspirator was used to remove  
21 rice hulls as described in U. S. Patent No. 4,066,012 to Satake and U. S. Patent No.  
22 5,678,477 to Satake et al.



1 In the Laboratory Husker a gap distance between the rollers is set so as to produce  
2 minimal breakage in the sample. The remaining overtails are then processed at that  
3 setting.

4 Analysis of the output from the rubber rollers indicate that the resulting product,  
5 as a percentage of total corn stock, is 7.10% large germ pieces, 2.66% large pieces of  
6 endosperm grit with adhering germ fragments, and 72.70% endosperm grit without  
7 adhering germ fragments. Passing the endosperm grit through a sifter having various  
8 sizes of mesh showed 58.66% of the total corn stock comprises endosperm grit that  
9 remains above a #6 Wire (3530 micron) mesh sifter.

10 The 7.10% large germ pieces consists of a high percentage of whole germs, which  
11 are ideal for efficient operation of further processing systems.

12 The 2.66% large pieces of endosperm grit with adhering germ may be retreated  
13 through the rubber roller friction process or diverted through an independent friction unit,  
14 depending on the capacity requirements of the user; however, such steps are not  
15 undertaken in the present example. Either step would result in separating additional clean  
16 endosperm grit from the germ fragments.

17 The foregoing disclosure and description of the invention is illustrative and  
18 explanatory thereof. Various changes in the details of the illustrated process may be  
19 made within the scope of the appended claims without departing from the spirit of the  
20 invention. The present invention should only be limited by the following claims and their  
21 legal equivalents.

22